

PATENT ABSTRACTS OF JAPAN

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(71)Applicant : MITSUBISHI MATERIALS SILICON CORP

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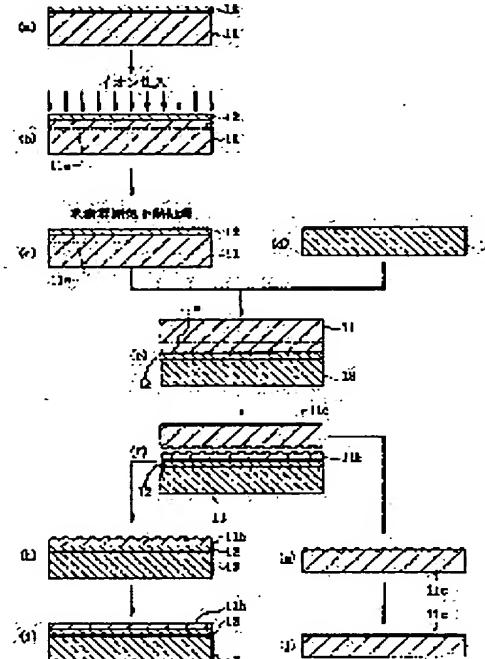
(72)Inventor : NAKAI TETSUYA
TOMIZAWA KENJI
NAKAJIMA TAKESHI

(54) MANUFACTURE OF SOI SUBSTRATE

(57)Abstract:

PROBLEM TO BE SOLVED: To improve the productivity of an SOI substrate, by effectively generating bubbles in an ion implantation area with a small amount of implanted ions, and dividing a semiconductor substrate at the ion implantation area.

SOLUTION: An oxidation film 12 is formed on a surface of a first silicon substrate 11. One or two kinds of ions, that are selected from a group consisting of a hydrogen gas ion, a hydrogen molecule ion, a helium ion, and a silicon ion, are implanted to the surface of the first substrate to form an ion implantation area 11a in the first substrate. The first substrate is subjected to a heating operation at 400° C or less in an atmosphere of hydrogen. The first substrate is overlaid to and is contact with a second silicon substrate 13 via the oxidation film 12. The first substrate is heated at 500 to 800° C while being contact with the second substrate, and the first substrate is separated from the second substrate at the ion implantation area 11a. Thus, a silicon layer 11b is formed on a surface of the second substrate. Further, the second substrate having the silicon layer 11b thereon is subjected to a heating operation.



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CLAIMS

[Claim(s)]

[Claim 1] The process which forms an oxide film (12) in the front face of the 1st silicon substrate (11), The hydrogen gas ion from the front face of said 1st silicon substrate (11), hydrogen content child ion, The process which pours in one sort or two sorts of ion chosen from the group which consists of helium ion and silicon ion, and forms an ion-implantation field (11a) parallel to said oxide film (12) in the interior of said 1st substrate (11), The process which heat-treats said 1st silicon substrate (11) at the temperature of 400 degrees C or less in a hydrogen ambient atmosphere, The process at which said 1st silicon substrate (11) is laid on top of the 2nd silicon substrate (13) which turns into a support substrate through said oxide film (12), and is stuck, Heat-treat at the temperature of 500~800 degrees C, sticking said 1st silicon substrate (11) to said 2nd silicon substrate (13), and said 1st silicon substrate (11) is separated from said 2nd silicon substrate (13) in said ion-implantation field (11a). The manufacture approach of a SOI substrate including the process which forms a silicon layer (11b) in the front face of said 2nd silicon substrate (13) by this, and the process which heat-treats further said 2nd silicon substrate (13) which has said silicon layer (11b) on a front face.

[Claim 2] The manufacture approach of a SOI substrate according to claim 1 that the injection rate of one sort or two sorts of ion chosen from the group which consists of hydrogen gas ion, hydrogen content child ion, helium ion, and silicon ion is 0.5×10^{16} to 3.5×10^{16} /cm².

[Claim 3] It is the manufacture approach of a SOI substrate according to claim 1 or 2 of pouring in said hydrogen gas ion or hydrogen content child ion after the impregnation sequence of said ion pours in said helium ion when the ion to pour in is hydrogen gas ion or hydrogen content child ion, and helium ion.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]**[0001]**

[Field of the Invention] This invention relates to the manufacture approach of a SOI (Silicon On Insulator) substrate of having prepared the semi-conductor layer on the insulator layer.

[0002]

[Description of the Prior Art] This kind of SOI substrate has attracted attention as a future ultra-large scale integrated circuit (ULSI) substrate. SIMOX which carries out annealing treatment at an elevated temperature, forms a pad silicon oxidizing zone in the field of the predetermined depth from this silicon substrate surface, and makes an active region the Si layer by the side of that front face after pouring high-concentration oxygen ion into the interior of the approach of making a silicon thin film depositing on the substrate which has the approach, ** insulation substrate, or the insulating thin film which sticks ** silicon substrates on the manufacture approach of this SOI substrate through an insulator layer on a front face, and ** silicon substrate — there is law etc. After injecting a hydrogen ion etc. into a semi-conductor substrate recently, an ion-implantation side to a support substrate as a superposition side for this semi-conductor substrate Moreover, superposition, Carry out the temperature up of this layered product to the temperature exceeding 500 degrees C, and an ion-implantation field is made to generate air bubbles. This separates the above-mentioned semi-conductor substrate from a support substrate in the above-mentioned ion-implantation field, and the manufacture approach of a thin semiconductor material film of having the thin film of a semi-conductor on the front face of a support substrate is proposed (JP,5-211128,A). By this approach, if ion can be poured into homogeneity from a front face inside a semi-conductor substrate, the semi-conductor substrate which has a semi-conductor layer with uniform thin thickness will be obtained. Moreover, if the oxide film is beforehand prepared in the front face of a support substrate, the SOI substrate which has the semi-conductor layer formed on the oxide film which is formed on a support substrate and this substrate by this approach, and acts as a pad oxide film, and this oxide film can be manufactured.

[0003]

[Problem(s) to be Solved by the Invention] However, by the manufacture approach of the above-mentioned conventional thin semiconductor material film, when injecting a hydrogen ion into a semi-conductor substrate, there was fault to which it must pour in with the dose of comparatively a lot of 3.5×10^{16} to $10 \times 10^{16} / \text{cm}^2$, and an ion implantation takes comparatively much time amount, therefore the productivity of a SOI substrate falls. The purpose of this invention makes an ion-implantation field generate air bubbles efficiently in a small ion injection rate, can separate a semi-conductor substrate in the above-mentioned ion-implantation field, and is to offer the manufacture approach of the SOI substrate which can improve the productivity of a SOI substrate.

[0004]

[Means for Solving the Problem] The process at which invention concerning claim 1 forms an oxide film 12 in the front face of the 1st silicon substrate 11 as shown in drawing 1, The hydrogen gas ion from the front face of the 1st silicon substrate 11, hydrogen content child ion,

The process which pours in one sort or two sorts of ion chosen from the group which consists of helium ion and silicon ion, and forms ion-implantation field 11a parallel to an oxide film 12 in the 1st substrate 11 interior, The process which heat-treats the 1st silicon substrate 11 at the temperature of 400 degrees C or less in a hydrogen ambient atmosphere, The process at which the 1st silicon substrate 11 is laid on top of the 2nd silicon substrate 13 which turns into a support substrate through an oxide film 12, and is stuck, Heat-treat at the temperature of 500–800 degrees C, sticking the 1st silicon substrate 11 to the 2nd silicon substrate 13, and the 1st silicon substrate 11 is separated from the 2nd silicon substrate 13 by ion-implantation field 11a. It is the manufacture approach of a SOI substrate including the process which forms silicon layer 11b in the front face of the 2nd silicon substrate 13 by this, and the process which heat-treats further the 2nd silicon substrate 13 which has silicon layer 11b on a front face. A dangling bond (hand for association that the silicon (Si) which the hydrogen atom has not combined has separated) is formed in ion-implantation field 11a as a result of an ion implantation. It combines with the hydrogen supplied by heat treatment of 400 degrees C or less in the hydrogen ambient atmosphere carried out by the degree like ion grouting, and termination of this dangling bond is carried out. In case the 1st silicon substrate 11 is stuck to the 2nd silicon substrate 13 and heat-treated behind, the hydrogen combined with the above-mentioned dangling bond in connection with the temperature up generates hydrogen gas. This hydrogen gas makes ion-implantation field 11a generate air bubbles, the 1st silicon substrate 11 breaks easily in ion-implantation field 11a with these air bubbles as the starting point, it dissociates from the 2nd silicon substrate 13, and, thereby, silicon layer 11b is formed in the front face of the 2nd silicon substrate 13. In addition, a hydrogen gas ambient atmosphere or a hydrogen plasma ambient atmosphere is called "hydrogen ambient atmosphere" on these specifications. In a hydrogen plasma ambient atmosphere, hydrogen will become activity.

[0005] Invention concerning claim 2 is invention concerning claim 1, and is the manufacture approach of a SOI substrate that the injection rate of one sort or two sorts of ion chosen from the group which consists of hydrogen gas ion, hydrogen content child ion, helium ion, and silicon ion is 0.5×10^{16} to $3.5 \times 10^{16}/\text{cm}^2$. When invention concerning claim 3 is invention concerning claim 1 or 2 and the ion to pour in is hydrogen gas ion or hydrogen content child ion, and helium ion, the impregnation sequence of said ion is the manufacture approach of a SOI substrate of pouring in said hydrogen gas ion or hydrogen content child ion, after pouring in said helium ion. Ion-implantation field 11a can be made to generate air bubbles in the total injection rate of little ion compared with 3.5×10^{16} to $10 \times 10^{16}/\text{cm}^2$ of ion injection rates cm² when pouring in the conventional hydrogen gas ion independently by the manufacture approach of the SOI substrate indicated by this claim 2 or 3.

[0006]

[Embodiment of the Invention] Next, the gestalt of operation of this invention is explained based on a drawing. As shown in drawing 1, in order to manufacture the SOI substrate of this invention, an oxide film 12 is formed in a front face for the 1st silicon substrate 11 which consists of a silicon wafer first by thermal oxidation (drawing 1 (a)). Subsequently, the ion implantation of the ion of either a hydrogen ion or helium ion and both sides is carried out to this 1st substrate 11 with the dose of 0.5×10^{16} to $3.5 \times 10^{16}/\text{cm}^2$, and ion-implantation field 11a is formed in the 1st substrate 11 interior in parallel with an oxide film 12 (drawing 1 (b)). That is, there is a method of pouring in hydrogen gas ion, hydrogen content child ion, or silicon ion in this ion implantation after pouring in the method of pouring in any one sort of ion of ** hydrogen gas ion, hydrogen content child ion, helium ion, or silicon ion, and ** helium ion. After pouring either of the above-mentioned ion in by the approach of ** here with the dose of 0.5×10^{16} to $3.5 \times 10^{16}/\text{cm}^2$ and pouring in helium ion by the approach of ** with the dose of 0.5×10^{16} to $3.5 \times 10^{16}/\text{cm}^2$, it is desirable to pour in hydrogen gas ion, hydrogen content child ion, or silicon ion with the dose of 0.5×10^{16} to $3.5 \times 10^{16}/\text{cm}^2$.

[0007] Subsequently, the 400 degrees C or less of the 1st substrate 11 are preferably heat-treated at the temperature of 300–400 degrees C in a hydrogen ambient atmosphere (drawing 1 (c)). If it exceeds 400 degrees C, before laying on top of the 2nd substrate 13, because there is a possibility that the 1st substrate 11 is ion-implantation field 11a and of by the way producing a

crack, it heat-treats below 400 degrees C. Subsequently, after having the same surface area as the 1st substrate 11 of the above, preparing the 2nd silicon substrate 13 which consists of a silicon wafer used as a support substrate (drawing 1 (d)) and washing both the substrates 11 and 13 by the RCA method, the 1st substrate 11 is piled up and stuck at a room temperature on the 2nd substrate 13 (drawing 1 (e)).

[0008] Subsequently, sticking the 1st substrate 11 to the 2nd substrate 13, in nitrogen-gas-atmosphere mind, a temperature up is preferably carried out to a 500-600-degree C temperature requirement, it holds for 5 - 30 minutes to this temperature requirement, and 500-800 degrees C of thin film separation heat treatments are performed. It is divided in the place whose 1st substrate 11 is ion-implantation field 11a by this, and separates into upside heavy-gage part 11c and silicon layer 11b with the thin lower part (drawing 1 (f)). It is because there is fault to which growth of air bubbles progresses and surface roughness increases when having limited the temperature of the above-mentioned heat treatment to 500-800 degrees C here has the fault which is not enough and 800 degrees C is exceeded. Next, temperature is lowered, heavy-gage part 11c is removed (drawing 1 (g)), and heat treatment which carries out the temperature up of the 2nd substrate 13 which has silicon layer 11b on a front face to the range of 900-1200 degrees C in oxygen or nitrogen-gas-atmosphere mind, and is held for 30 - 120 minutes to this temperature requirement is performed (drawing 1 (h)). This heat treatment is heat treatment which strengthens lamination to the 2nd substrate 13 of silicon layer 11b. Finally, the separation side of silicon layer 11b and the separation side of heavy-gage part 11c are ground, respectively (touch polishing), and are graduated (drawing 1 (i) and drawing 1 (j)). Thereby, the 2nd substrate 13 turns into a SOI substrate, and can use heavy-gage part 11c for manufacture of a SOI substrate again as a new silicon substrate.

[0009]

[Example] Next, in order to show the concrete mode of this invention, the example of this invention is explained with the example of a comparison.

As shown in <example 1> drawing 1 (a), the silicon substrate 11 which consists of a silicon wafer with a thickness of 625 micrometers was oxidized thermally, and the oxide film 12 with a thickness of 400nm was formed in the front face. The electrical potential difference of 70keV(s) was impressed to this silicon substrate 11, and hydrogen gas ion (H⁺) was poured in 1×10^{16} -/ cm^2 (drawing 1 (b)). Subsequently, this silicon substrate 11 was heat-treated for 60 minutes at the temperature of 350 degrees C in the hydrogen gas ambient atmosphere (drawing 1 R > 1 (c)). This heat-treated silicon substrate 11 was used as the silicon substrate of an example 1.

[0010] If it removed having poured in helium ion (helium+) 1×10^{16} -/ cm^2 instead of <example 2> hydrogen gas ion, the approach of an example 1 was repeated substantially and the silicon substrate of an example 2 was manufactured.

[0011] After injecting helium ion into the <example 3> silicon substrate 11 0.5×10^{16} -/ cm^2 , if it removed having poured in hydrogen gas ion 0.5×10^{16} -/ cm^2 , the approach of an example 1 was repeated substantially and the silicon substrate of an example 3 was manufactured.

[0012] If it removed having not carried out heat treatment in the <example 1 of comparison> hydrogen gas ambient atmosphere, and having poured in hydrogen gas ion with the dose of 1×10^{16} -/ cm^2 , the approach of an example 1 was repeated substantially and the silicon substrate of the example 1 of a comparison was manufactured.

[0013] After holding the silicon substrate of the <comparative study and evaluation> examples 1-3 and the example 1 of a comparison for 30 minutes at 600 degrees C in the same heat treatment as thin film separation heat treatment, i.e., nitrogen-gas-atmosphere mind, it investigated whether the blister (blister) occurred on the oxide film front face of each silicon substrate. The result is shown in Table 1. In addition, when the reason for having investigated the existence of generating of the blister on the front face of an oxide film was explained after the above-mentioned heat treatment, the 1st substrate 11 and the 2nd substrate 13 are stuck, and it heat-treats, in order to manufacture a SOI substrate by the approach of this invention, and it is required to generate air bubbles at ion-implantation field 11b of the 1st substrate 11 and these air bubbles are generated, it is for a blister to occur on oxide film 12 front face. That is, it is because the existence of generating of the air bubbles in ion-implantation field 11b can

be judged by the existence of generating of a blister.

[0014]

[Table 1]

	第1回目の 注入イオン 及び その注入量 ($\times 10^{16}/\text{cm}^2$)	第2回目の 注入イオン 及び その注入量 ($\times 10^{16}/\text{cm}^2$)	イオンの トータル 注入量 ($\times 10^{16}/\text{cm}^2$)	ブリスタ (火ぶくれ) の発生の 有無
実施例 1	H ⁺ 1	-	1	有り
実施例 2	H e ⁺ 1	-	1	有り
実施例 3	H e ⁺ 0.5	H ⁺ 0.5	1	有り
比較例 1	H ⁺ 1	-	1	無し

[0015] In the example 1 of a comparison, a blister did not occur to the blister having occurred in the examples 1–3 so that clearly from Table 1. This is for hydrogen being supplied for an ion injection rate by heat treatment in the hydrogen gas ambient atmosphere after an ion implantation at least in the examples 1–3, and this hydrogen combining with the dangling bond of the silicon (Si) of ion-implantation field 11a, generating the air bubbles of hydrogen gas, in case the 1st substrate 11 and the 2nd substrate are stuck behind and it heat-treats, and producing a blister. On the other hand, in the example 1 of a comparison, since heat treatment in the hydrogen ambient atmosphere after an ion implantation is not carried out, if there are few ion injection rates in this way, a blister will not occur. A blister is produced, although there are few total injection rates of ion than examples 1 and 2 in order to make into Sharp impregnation part cloth width of the hydrogen gas ion which ion-implantation field 11a was effectively formed compared with light hydrogen gas ion relatively, and was poured in next by pouring in helium ion with heavy mass previously in the example 3 especially.

[0016]

[Effect of the Invention] According to this invention, an oxide film is formed in the front face of the 1st silicon substrate as stated above. One sort or two sorts of ion chosen from the group which consists of hydrogen gas ion, hydrogen content child ion, helium ion, and silicon ion is poured in from the front face of the 1st silicon substrate. Form an ion-implantation field in the interior of the 1st silicon substrate, and the 1st silicon substrate is heat-treated at the temperature of 400 degrees C or less in a hydrogen ambient atmosphere. Since it was made to heat-treat laying the 1st silicon substrate on top of the 2nd silicon substrate, sticking it through the above-mentioned oxide film, and sticking the 1st silicon substrate to the 2nd silicon substrate, air bubbles are efficiently generated to an ion-implantation field in a small ion injection rate. That is, in this invention, the 1st silicon substrate is efficiently separable into a heavy-gage part and a thin silicon layer in an ion-implantation field. Consequently, since an ion implantation can be performed in a short time, the productivity of a SOI substrate can be improved.

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TECHNICAL FIELD

[Field of the Invention] This invention relates to the manufacture approach of a SOI (Silicon On Insulator) substrate of having prepared the semi-conductor layer on the insulator layer.

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PRIOR ART

[Description of the Prior Art] This kind of SOI substrate has attracted attention as a future ultra-large scale integrated circuit (ULSI) substrate. SIMOX which carries out annealing treatment at an elevated temperature, forms a pad silicon oxidizing zone in the field of the predetermined depth from this silicon substrate surface, and makes an active region the Si layer by the side of that front face after pouring high-concentration oxygen ion into the interior of the approach of making a silicon thin film depositing on the substrate which has the approach, ** insulation substrate, or the insulating thin film which sticks ** silicon substrates on the manufacture approach of this SOI substrate through an insulator layer on a front face, and ** silicon substrate — there is law etc. After injecting a hydrogen ion etc. into a semi-conductor substrate recently, an ion-implantation side to a support substrate as a superposition side for this semi-conductor substrate Moreover, superposition, Carry out the temperature up of this layered product to the temperature exceeding 500 degrees C, and an ion-implantation field is made to generate air bubbles. This separates the above-mentioned semi-conductor substrate from a support substrate in the above-mentioned ion-implantation field, and the manufacture approach of a thin semiconductor material film of having the thin film of a semi-conductor on the front face of a support substrate is proposed (JP,5-211128,A). By this approach, if ion can be poured into homogeneity from a front face inside a semi-conductor substrate, the semi-conductor substrate which has a semi-conductor layer with uniform thin thickness will be obtained. Moreover, if the oxide film is beforehand prepared in the front face of a support substrate, the SOI substrate which has the semi-conductor layer formed on the oxide film which is formed on a support substrate and this substrate by this approach, and acts as a pad oxide film, and this oxide film can be manufactured.

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EFFECT OF THE INVENTION

[Effect of the Invention] According to this invention, an oxide film is formed in the front face of the 1st silicon substrate as stated above. One sort or two sorts of ion chosen from the group which consists of hydrogen gas ion, hydrogen content child ion, helium ion, and silicon ion is poured in from the front face of the 1st silicon substrate. Form an ion-implantation field in the interior of the 1st silicon substrate, and the 1st silicon substrate is heat-treated at the temperature of 400 degrees C or less in a hydrogen ambient atmosphere. Since it was made to heat-treat laying the 1st silicon substrate on top of the 2nd silicon substrate, sticking it through the above-mentioned oxide film, and sticking the 1st silicon substrate to the 2nd silicon substrate, air bubbles are efficiently generated to an ion-implantation field in a small ion injection rate. That is, in this invention, the 1st silicon substrate is efficiently separable into a heavy-gage part and a thin silicon layer in an ion-implantation field. Consequently, since an ion implantation can be performed in a short time, the productivity of a SOI substrate can be improved.

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, by the manufacture approach of the above-mentioned conventional thin semiconductor material film, when injecting a hydrogen ion into a semi-conductor substrate, there was fault to which it must pour in with the dose of comparatively a lot of 3.5×10^{16} to $10 \times 10^{16}/\text{cm}^2$, and an ion implantation takes comparatively much time amount, therefore the productivity of a SOI substrate falls. The purpose of this invention makes an ion-implantation field generate air bubbles efficiently in a small ion injection rate, can separate a semi-conductor substrate in the above-mentioned ion-implantation field, and is to offer the manufacture approach of the SOI substrate which can improve the productivity of a SOI substrate.

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MEANS

[Means for Solving the Problem] The process at which invention concerning claim 1 forms an oxide film 12 in the front face of the 1st silicon substrate 11 as shown in drawing 1. The hydrogen gas ion from the front face of the 1st silicon substrate 11, hydrogen content child ion, The process which pours in one sort or two sorts of ion chosen from the group which consists of helium ion and silicon ion, and forms ion-implantation field 11a parallel to an oxide film 12 in the 1st substrate 11 interior, The process which heat-treats the 1st silicon substrate 11 at the temperature of 400 degrees C or less in a hydrogen ambient atmosphere, The process at which the 1st silicon substrate 11 is laid on top of the 2nd silicon substrate 13 which turns into a support substrate through an oxide film 12, and is stuck, Heat-treat at the temperature of 500-800 degrees C, sticking the 1st silicon substrate 11 to the 2nd silicon substrate 13, and the 1st silicon substrate 11 is separated from the 2nd silicon substrate 13 by ion-implantation field 11a. It is the manufacture approach of a SOI substrate including the process which forms silicon layer 11b in the front face of the 2nd silicon substrate 13 by this, and the process which heat-treats further the 2nd silicon substrate 13 which has silicon layer 11b on a front face. A dangling bond (hand for association that the silicon (Si) which the hydrogen atom has not combined has separated) is formed in ion-implantation field 11a as a result of an ion implantation. It combines with the hydrogen supplied by heat treatment of 400 degrees C or less in the hydrogen ambient atmosphere carried out by the degree like ion grouting, and termination of this dangling bond is carried out. In case the 1st silicon substrate 11 is stuck to the 2nd silicon substrate 13 and heat-treated behind, the hydrogen combined with the above-mentioned dangling bond in connection with the temperature up generates hydrogen gas. This hydrogen gas makes ion-implantation field 11a generate air bubbles, the 1st silicon substrate 11 breaks easily in ion-implantation field 11a with these air bubbles as the starting point, it dissociates from the 2nd silicon substrate 13, and, thereby, silicon layer 11b is formed in the front face of the 2nd silicon substrate 13. In addition, a hydrogen gas ambient atmosphere or a hydrogen plasma ambient atmosphere is called "hydrogen ambient atmosphere" on these specifications. In a hydrogen plasma ambient atmosphere, hydrogen will become activity.

[0005] Invention concerning claim 2 is invention concerning claim 1, and is the manufacture approach of a SOI substrate that the injection rate of one sort or two sorts of ion chosen from the group which consists of hydrogen gas ion, hydrogen content child ion, helium ion, and silicon ion is 0.5×10^{16} to $3.5 \times 10^{16}/\text{cm}^2$. When invention concerning claim 3 is invention concerning claim 1 or 2 and the ion to pour in is hydrogen gas ion or hydrogen content child ion, and helium ion, the impregnation sequence of said ion is the manufacture approach of a SOI substrate of pouring in said hydrogen gas ion or hydrogen content child ion, after pouring in said helium ion. Ion-implantation field 11a can be made to generate air bubbles in the total injection rate of little ion compared with 3.5×10^{16} to $10 \times 10^{16}/\text{cm}^2$ of ion injection rates cm² when pouring in the conventional hydrogen gas ion independently by the manufacture approach of the SOI substrate indicated by this claim 2 or 3.

[0006]

[Embodiment of the Invention] Next, the gestalt of operation of this invention is explained based on a drawing. As shown in drawing 1, in order to manufacture the SOI substrate of this

invention, an oxide film 12 is formed in a front face for the 1st silicon substrate 11 which consists of a silicon wafer first by thermal oxidation (drawing 1 (a)). Subsequently, the ion implantation of the ion of either a hydrogen ion or helium ion and both sides is carried out to this 1st substrate 11 with the dose of 0.5×10^{16} to $3.5 \times 10^{16}/\text{cm}^2$, and ion-implantation field 11a is formed in the 1st substrate 11 interior in parallel with an oxide film 12 (drawing 1 (b)). That is, there is a method of pouring in hydrogen gas ion, hydrogen content child ion, or silicon ion in this ion implantation after pouring in the method of pouring in any one sort of ion of ** hydrogen gas ion, hydrogen content child ion, helium ion, or silicon ion, and ** helium ion. After pouring either of the above-mentioned ion in by the approach of ** here with the dose of 0.5×10^{16} to $3.5 \times 10^{16}/\text{cm}^2$ and pouring in helium ion by the approach of ** with the dose of 0.5×10^{16} to $3.5 \times 10^{16}/\text{cm}^2$, it is desirable to pour in hydrogen gas ion, hydrogen content child ion, or silicon ion with the dose of 0.5×10^{16} to $3.5 \times 10^{16}/\text{cm}^2$.

[0007] Subsequently, the 400 degrees C or less of the 1st substrate 11 are preferably heat-treated at the temperature of 300–400 degrees C in a hydrogen ambient atmosphere (drawing 1 (c)). If it exceeds 400 degrees C, before laying on top of the 2nd substrate 13, because there is a possibility that the 1st substrate 11 is ion-implantation field 11a and of by the way producing a crack, it heat-treats below 400 degrees C. Subsequently, after having the same surface area as the 1st substrate 11 of the above, preparing the 2nd silicon substrate 13 which consists of a silicon wafer used as a support substrate (drawing 1 (d)) and washing both the substrates 11 and 13 by the RCA method, the 1st substrate 11 is piled up and stuck at a room temperature on the 2nd substrate 13 (drawing 1 (e)).

[0008] Subsequently, sticking the 1st substrate 11 to the 2nd substrate 13, in nitrogen-gas-atmosphere mind, a temperature up is preferably carried out to a 500–600-degree C temperature requirement, it holds for 5 – 30 minutes to this temperature requirement, and 500–800 degrees C of thin film separation heat treatments are performed. It is divided in the place whose 1st substrate 11 is ion-implantation field 11a by this, and separates into upside heavy-gage part 11c and silicon layer 11b with the thin lower part (drawing 1 (f)). It is because there is fault to which growth of air bubbles progresses and surface roughness increases when having limited the temperature of the above-mentioned heat treatment to 500–800 degrees C here has the fault which is not enough and 800 degrees C is exceeded. Next, temperature is lowered, heavy-gage part 11c is removed (drawing 1 (g)), and heat treatment which carries out the temperature up of the 2nd substrate 13 which has silicon layer 11b on a front face to the range of 900–1200 degrees C in oxygen or nitrogen-gas-atmosphere mind, and is held for 30 – 120 minutes to this temperature requirement is performed (drawing 1 (h)). This heat treatment is heat treatment which strengthens lamination to the 2nd substrate 13 of silicon layer 11b. Finally, the separation side of silicon layer 11b and the separation side of heavy-gage part 11c are ground, respectively (touch polishing), and are graduated (drawing 1 (i) and drawing 1 (j)). Thereby, the 2nd substrate 13 turns into a SOI substrate, and can use heavy-gage part 11c for manufacture of a SOI substrate again as a new silicon substrate.

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EXAMPLE

[Example] Next, in order to show the concrete mode of this invention, the example of this invention is explained with the example of a comparison.

As shown in <example 1> drawing 1 (a), the silicon substrate 11 which consists of a silicon wafer with a thickness of 625 micrometers was oxidized thermally, and the oxide film 12 with a thickness of 400nm was formed in the front face. The electrical potential difference of 70keV(s) was impressed to this silicon substrate 11, and hydrogen gas ion (H+) was poured in 1×10^{16} /cm² (drawing 1 (b)). Subsequently, this silicon substrate 11 was heat-treated for 60 minutes at the temperature of 350 degrees C in the hydrogen gas ambient atmosphere (drawing 1 R> 1 (c)). This heat-treated silicon substrate 11 was used as the silicon substrate of an example 1.

[0010] If it removed having poured in helium ion (helium+) 1×10^{16} /cm² instead of <example 2> hydrogen gas ion, the approach of an example 1 was repeated substantially and the silicon substrate of an example 2 was manufactured.

[0011] After injecting helium ion into the <example 3> silicon substrate 11 0.5×10^{16} /cm², if it removed having poured in hydrogen gas ion 0.5×10^{16} /cm², the approach of an example 1 was repeated substantially and the silicon substrate of an example 3 was manufactured.

[0012] If it removed having not carried out heat treatment in the <example 1 of comparison> hydrogen gas ambient atmosphere, and having poured in hydrogen gas ion with the dose of 1×10^{16} /cm², the approach of an example 1 was repeated substantially and the silicon substrate of the example 1 of a comparison was manufactured.

[0013] After holding the silicon substrate of the <comparative study and evaluation> examples 1~3 and the example 1 of a comparison for 30 minutes at 600 degrees C in the same heat treatment as thin film separation heat treatment, i.e., nitrogen-gas-atmosphere mind, it investigated whether the blister (blister) occurred on the oxide film front face of each silicon substrate. The result is shown in Table 1. In addition, when the reason for having investigated the existence of generating of the blister on the front face of an oxide film was explained after the above-mentioned heat treatment, the 1st substrate 11 and the 2nd substrate 13 are stuck, and it heat-treats, in order to manufacture a SOI substrate by the approach of this invention, and it is required to generate air bubbles at ion-implantation field 11b of the 1st substrate 11 and these air bubbles are generated, it is for a blister to occur on oxide film 12 front face. That is, it is because the existence of generating of the air bubbles in ion-implantation field 11b can be judged by the existence of generating of a blister.

[0014]

[Table 1]

	第1回目の 注入イオン 及び その注入量 ($\times 10^{16}/\text{cm}^2$)	第2回目の 注入イオン 及び その注入量 ($\times 10^{16}/\text{cm}^2$)	イオンの トータル 注入量 ($\times 10^{16}/\text{cm}^2$)	ブリスタ (火ぶくれ) の発生の 有無
実施例1	H ⁺ 1	-	1	有り
実施例2	H e ⁺ 1	-	1	有り
実施例3	H e ⁺ 0.5	H ⁺ 0.5	1	有り
比較例1	H ⁺ 1	-	1	無し

[0015] In the example 1 of a comparison, a blister did not occur to the blister having occurred in the examples 1–3 so that clearly from Table 1. This is for hydrogen being supplied for an ion injection rate by heat treatment in the hydrogen gas ambient atmosphere after an ion implantation at least in the examples 1–3, and this hydrogen combining with the dangling bond of the silicon (Si) of ion-implantation field 11a, generating the air bubbles of hydrogen gas, in case the 1st substrate 11 and the 2nd substrate are stuck behind and it heat-treats, and producing a blister. On the other hand, in the example 1 of a comparison, since heat treatment in the hydrogen ambient atmosphere after an ion implantation is not carried out, if there are few ion injection rates in this way, a blister will not occur. A blister is produced, although there are few total injection rates of ion than examples 1 and 2 in order to make into Sharp impregnation part cloth width of the hydrogen gas ion which ion-implantation field 11a was effectively formed compared with light hydrogen gas ion relatively, and was poured in next by pouring in helium ion with heavy mass previously in the example 3 especially.

[Translation done.]

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] Drawing showing the manufacture approach of the SOI substrate of this invention operation gestalt in order of a process.

[Description of Notations]

- 11 1st Silicon Substrate
- 11a Ion-implantation field
- 11b Silicon layer
- 12 Oxide Film
- 13 2nd Silicon Substrate

[Translation done.]

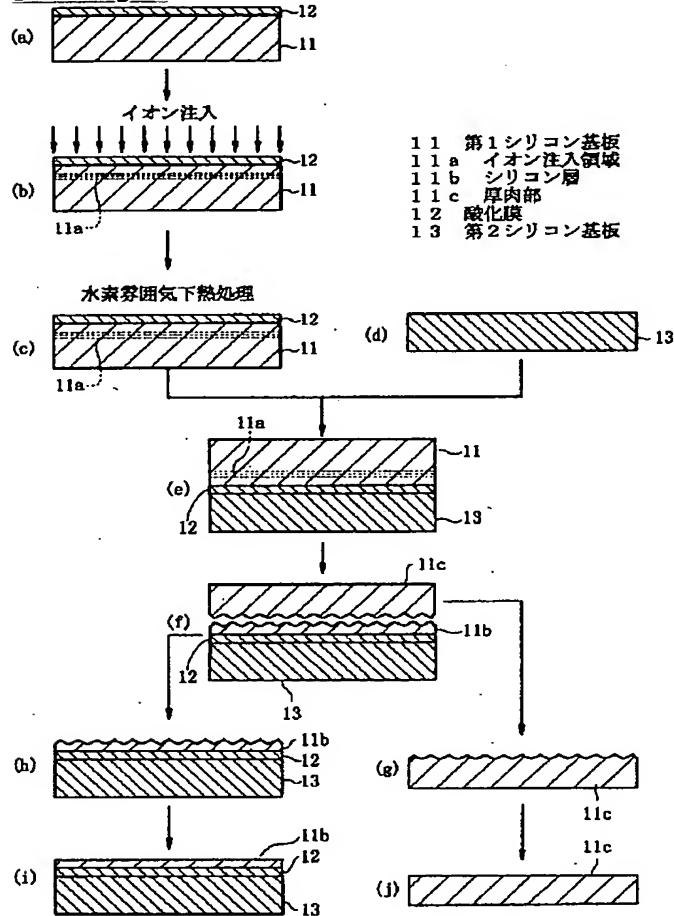
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DRAWINGS

[Drawing 1]



[Translation done.]

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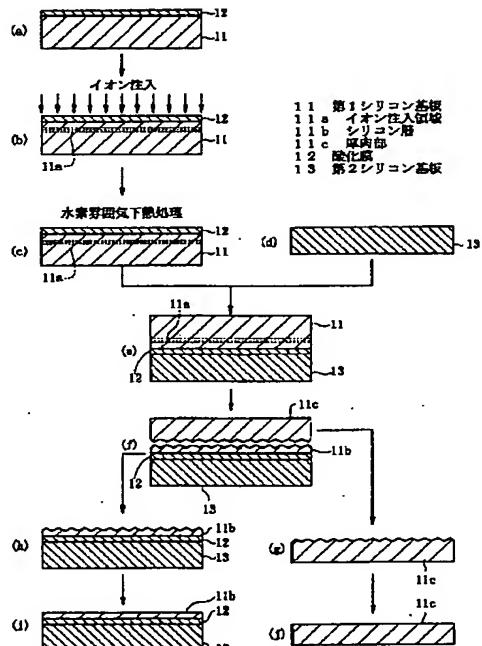
(71)出願人 000228925
三菱マテリアルシリコン株式会社
東京都千代田区大手町一丁目5番1号
(72)発明者 中井 哲弥
東京都千代田区大手町1丁目5番1号 三菱マテリアルシリコン株式会社内
(72)発明者 富澤 慶治
東京都千代田区大手町1丁目5番1号 三菱マテリアルシリコン株式会社内
(72)発明者 中嶋 健
東京都千代田区大手町1丁目5番1号 三菱マテリアルシリコン株式会社内
(74)代理人 弁理士 須田 正義

(54)【発明の名称】 SOI基板の製造方法

(57)【要約】

【課題】 少ないイオン注入量で効率的にイオン注入領域に気泡を発生させて半導体基板をイオン注入領域で分離し、SOI基板の生産性を向上させる。

【解決手段】 第1シリコン基板11の表面に酸化膜12を形成する。第1基板の表面から水素ガスイオン、水素分子イオン、ヘリウムイオン及びシリコンイオンからなる群から選ばれた1種又は2種のイオンを注入して第1基板内部にイオン注入領域11aを形成する。第1基板を水素雰囲気中400°C以下の温度で熱処理する。第1基板を酸化膜12を介して第2シリコン基板13に重ね合わせて密着させる。第1基板を第2基板に密着させたまま500~800°Cの温度で熱処理して第1基板をイオン注入領域11aで第2基板から分離し、これにより第2基板の表面にシリコン層11bを形成する。表面にシリコン層11bを有する第2基板を更に熱処理する。



【特許請求の範囲】

【請求項1】 第1シリコン基板(11)の表面に酸化膜(12)を形成する工程と、

前記第1シリコン基板(11)の表面から水素ガスイオン、水素分子イオン、ヘリウムイオン及びシリコンイオンからなる群から選ばれた1種又は2種のイオンを注入して前記第1基板(11)内部に前記酸化膜(12)に平行なイオン注入領域(11a)を形成する工程と、

前記第1シリコン基板(11)を水素雰囲気中において400°C以下の温度で熱処理する工程と、

前記第1シリコン基板(11)を前記酸化膜(12)を介して支持基板となる第2シリコン基板(13)に重ね合わせて密着させる工程と、

前記第1シリコン基板(11)を前記第2シリコン基板(13)に密着させたまま500~800°Cの温度で熱処理して前記第1シリコン基板(11)を前記イオン注入領域(11a)で前記第2シリコン基板(13)から分離し、これにより前記第2シリコン基板(13)の表面にシリコン層(11b)を形成する工程と、

表面に前記シリコン層(11b)を有する前記第2シリコン基板(13)を更に熱処理する工程とを含むSOI基板の製造方法。

【請求項2】 水素ガスイオン、水素分子イオン、ヘリウムイオン及びシリコンイオンからなる群から選ばれた1種又は2種のイオンの注入量が $0.5 \times 10^{16} \sim 3.5 \times 10^{16} / cm^2$ である請求項1記載のSOI基板の製造方法。

【請求項3】 注入するイオンが水素ガスイオン又は水素分子イオンとヘリウムイオンであるとき前記イオンの注入順序は前記ヘリウムイオンを注入した後に前記水素ガスイオン又は水素分子イオンを注入する請求項1又は2記載のSOI基板の製造方法。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】 本発明は、絶縁膜上に半導体層を設けたSOI(Silicon On Insulator)基板の製造方法に関するものである。

【0002】

【従来の技術】 この種のSOI基板は将来の超高集積回路(ULSI)基板として注目されてきている。このSOI基板の製造方法には、①シリコン基板同士を絶縁膜を介して貼り合わせる方法、②絶縁性基板又は絶縁性薄膜を表面に有する基板の上にシリコン薄膜を堆積させる方法、③シリコン基板の内部に高濃度の酸素イオンを注入した後、高温でアニール処理してこのシリコン基板表面から所定の深さの領域に埋込みシリコン酸化層を形成し、その表面側のSi層を活性領域とするSIMOX法などがある。また最近、半導体基板に水素イオン等の注入を行った後に、この半導体基板をイオン注入面を重ね合せ面として支持基板に重ね合せ、この積層体を500

°Cを越える温度に昇温してイオン注入領域に気泡を発生させ、これにより上記半導体基板を上記イオン注入領域で支持基板から分離し、支持基板の表面に半導体の薄膜を有する薄い半導体材料フィルムの製造方法が提案されている(特開平5-211128)。この方法では、イオンを半導体基板の内部に表面から均一に注入できれば、均一な厚さの薄い半導体層を有する半導体基板が得られる。また支持基板の表面に予め酸化膜を設けておけば、この方法により支持基板とこの基板上に形成された埋込み酸化膜として作用する酸化膜との酸化膜上に形成された半導体層とを有するSOI基板を製造することができる。

【0003】

【発明が解決しようとする課題】 しかし、上記従来の薄い半導体材料フィルムの製造方法では、半導体基板に水素イオンを注入するときに、比較的多量の $3.5 \times 10^{16} \sim 10 \times 10^{16} / cm^2$ のドーズ量で注入しなければならず、イオン注入に比較的多くの時間を要し、そのためSOI基板の生産性が低下する不具合があった。本発明の目的は、少ないイオン注入量で効率的にイオン注入領域に気泡を発生させて半導体基板を上記イオン注入領域で分離でき、SOI基板の生産性を向上できるSOI基板の製造方法を提供することにある。

【0004】

【課題を解決するための手段】 請求項1に係る発明は、図1に示すように、第1シリコン基板11の表面に酸化膜12を形成する工程と、第1シリコン基板11の表面から水素ガスイオン、水素分子イオン、ヘリウムイオン及びシリコンイオンからなる群から選ばれた1種又は2種のイオンを注入して第1基板11内部に酸化膜12に平行なイオン注入領域11aを形成する工程と、第1シリコン基板11を水素雰囲気中において400°C以下の温度で熱処理する工程と、第1シリコン基板11を酸化膜12を介して支持基板となる第2シリコン基板13に重ね合わせて密着させる工程と、第1シリコン基板11を第2シリコン基板13に密着させたまま500~800°Cの温度で熱処理して第1シリコン基板11をイオン注入領域11aで第2シリコン基板13から分離し、これにより第2シリコン基板13の表面にシリコン層11bを形成する工程と、表面にシリコン層11bを有する第2シリコン基板13を更に熱処理する工程とを含むSOI基板の製造方法である。イオン注入領域11aにはイオン注入の結果、ダングリングボンド(水素原子が結合していないケイ素(Si)の遊離している結合用の手)が形成される。このダングリングボンドはイオン注入工程の後に実施される水素雰囲気中の400°C以下の熱処理により供給される水素と結合して終端される。後に第1シリコン基板11を第2シリコン基板13に密着させて熱処理する際に、昇温に伴って上記ダングリングボンドに結合した水素が水素ガスを発生する。この水

素ガスがイオン注入領域11aに気泡を発生させ、この気泡を起点として第1シリコン基板11がイオン注入領域11aで容易に割れて、第2シリコン基板13から分離し、これにより第2シリコン基板13の表面にシリコン層11bが形成される。なお、本明細書で「水素雰囲気」とは水素ガス雰囲気又は水素プラズマ雰囲気をいう。水素プラズマ雰囲気中では水素はより活性なものとなる。

【0005】請求項2に係る発明は、請求項1に係る発明であって、水素ガスイオン、水素分子イオン、ヘリウムイオン及びシリコンイオンからなる群から選ばれた1種又は2種のイオンの注入量が $0.5 \times 10^{16} \sim 3.5 \times 10^{16}/\text{cm}^2$ であるSOI基板の製造方法である。

請求項3に係る発明は、請求項1又は2に係る発明であって、注入するイオンが水素ガスイオン又は水素分子イオンとヘリウムイオンであるとき前記イオンの注入順序は前記ヘリウムイオンを注入した後に前記水素ガスイオン又は水素分子イオンを注入するSOI基板の製造方法である。この請求項2又は3に記載されたSOI基板の製造方法では、従来の水素ガスイオンを単独で注入したときのイオン注入量 $3.5 \times 10^{16} \sim 10 \times 10^{16}/\text{cm}^2$ と比べて少ないイオンのトータル注入量で、イオン注入領域11aに気泡を発生させることができる。

【0006】

【発明の実施の形態】次に本発明の実施の形態を図面に基づいて説明する。図1に示すように、本発明のSOI基板を製造するには、先ずシリコンウェーハからなる第1シリコン基板11を熱酸化により表面に酸化膜12を形成する(図1(a))。次いでこの第1基板11に水素イオン又はヘリウムイオンのいずれか一方又は双方のイオンを $0.5 \times 10^{16} \sim 3.5 \times 10^{16}/\text{cm}^2$ のドーズ量でイオン注入して、第1基板11内部にイオン注入領域11aを酸化膜12と平行に形成する(図1(b))。即ち、このイオン注入には、①水素ガスイオン、水素分子イオン、ヘリウムイオン又はシリコンイオンのいずれか1種のイオンを注入する方法、及び②ヘリウムイオンを注入後、水素ガスイオン、水素分子イオン又はシリコンイオンを注入する方法がある。ここで①の方法では上記イオンのいずれかを $0.5 \times 10^{16} \sim 3.5 \times 10^{16}/\text{cm}^2$ のドーズ量で注入し、②の方法ではヘリウムイオンを $0.5 \times 10^{16} \sim 3.5 \times 10^{16}/\text{cm}^2$ のドーズ量で注入した後、水素ガスイオン、水素分子イオン又はシリコンイオンを $0.5 \times 10^{16} \sim 3.5 \times 10^{16}/\text{cm}^2$ のドーズ量で注入することが好ましい。

【0007】次いで第1基板11を水素雰囲気中において 400°C 以下、好ましくは $300 \sim 400^\circ\text{C}$ の温度で熱処理する(図1(c))。 400°C 以下で熱処理するのは、 400°C を超えると第2基板13に重ね合せる前に第1基板11がイオン注入領域11aのところで割れ

を生じる恐れがあるためである。次いで上記第1基板11と同一表面積を有し、支持基板となるシリコンウェーハからなる第2シリコン基板13を用意し(図1(d))、両基板11、13をRCA法により洗浄した後、第2基板13上に第1基板11を室温で重ね合せて密着させる(図1(e))。

【0008】次いで第1基板11を第2基板13に密着させたまま窒素雰囲気中で $500 \sim 800^\circ\text{C}$ 、好ましくは $500 \sim 600^\circ\text{C}$ の温度範囲に昇温し、この温度範囲に5~30分間保持して薄膜分離熱処理を行う。これにより第1基板11がイオン注入領域11aのところで割れて上部の厚肉部11cと下部の薄いシリコン層11bに分離する(図1(f))。ここで、上記熱処理の温度を $500 \sim 800^\circ\text{C}$ に限定したのは、 500°C 未満では図1(c)で示した上記水素雰囲気中の熱処理によって第1基板11内に供給された水素による気泡内圧の上昇が十分でない不具合があり、 800°C を越えると気泡の成長が進んで表面粗さが増大する不具合があるからである。次に温度を下げて、厚肉部11cを取除き(図1(g))、表面にシリコン層11bを有する第2基板13を酸素又は窒素雰囲気中で $900 \sim 1200^\circ\text{C}$ の範囲に昇温し、この温度範囲に30~120分間保持する熱処理を行う(図1(h))。この熱処理はシリコン層11bの第2基板13への貼合せを強固にする熱処理である。最後にシリコン層11bの分離面及び厚肉部11cの分離面をそれぞれ研磨(タッチポリッシング)して平滑化する(図1(i)及び図1(j))。これにより第2基板13はSOI基板となり、厚肉部11cは新たなシリコン基板として再びSOI基板の製造に使用できる。

【0009】

【実施例】次に本発明の具体的な態様を示すために、本発明の実施例を比較例とともに説明する。

<実施例1>図1(a)に示すように、厚さ $625\mu\text{m}$ のシリコンウェーハからなるシリコン基板11を熱酸化して表面に厚さ 400nm の酸化膜12を形成した。このシリコン基板11に 70keV の電圧を印加して水素ガスイオン(H^+)を $1 \times 10^{16}/\text{cm}^2$ 注入した(図1(b))。次いでこのシリコン基板11を水素ガス雰囲気中において 350°C の温度で60分間熱処理した(図1(c))。この熱処理されたシリコン基板11を実施例1のシリコン基板とした。

【0010】<実施例2>水素ガスイオンの代りにヘリウムイオン(He^+)を $1 \times 10^{16}/\text{cm}^2$ 注入したこと除いては実質的に実施例1の方法を繰返して実施例2のシリコン基板を製造した。

【0011】<実施例3>シリコン基板11にヘリウムイオンを $0.5 \times 10^{16}/\text{cm}^2$ 注入した後に、水素ガスイオンを $0.5 \times 10^{16}/\text{cm}^2$ 注入したことを除いては実質的に実施例1の方法を繰返して実施例3のシリ

コン基板を製造した。

【0012】<比較例1>水素ガス雰囲気中における熱処理を実施せず、また $1 \times 10^{16}/\text{cm}^2$ のドーズ量で水素ガスイオンを注入したことを除いては実質的に実施例1の方法を繰返して比較例1のシリコン基板を製造した。

【0013】<比較試験及び評価>実施例1～3及び比較例1のシリコン基板を薄膜分離熱処理と同一の熱処理、即ち窒素雰囲気中で 600°C に30分間保持した後に、各シリコン基板の酸化膜表面にブリスタ（火ぶくれ）が発生したか否かを調べた。その結果を表1に示 *

	第1回目の 注入イオン 及び その注入量 ($\times 10^{16}/\text{cm}^2$)	第2回目の 注入イオン 及び その注入量 ($\times 10^{16}/\text{cm}^2$)	イオンの トータル 注入量 ($\times 10^{16}/\text{cm}^2$)	ブリスタ (火ぶくれ) の発生の 有無
実施例1	H^+ 1	—	1	有り
実施例2	He^+ 1	—	1	有り
実施例3	He^+ 0.5	H^+ 0.5	1	有り
比較例1	H^+ 1	—	1	無し

【0015】表1から明らかなように、実施例1～3ではブリスタが発生したのに対し、比較例1ではブリスタが発生しなかった。これは、実施例1～3ではイオン注入量が少なくて、イオン注入後の水素ガス雰囲気中の熱処理により水素が供給され、この水素がイオン注入領域11aのケイ素(Si)のダングリングボンドに結合し、後に第1基板11と第2基板を密着させて加熱処理する際に水素ガスの気泡を発生し、ブリスタを生じるためである。これに対し、比較例1ではイオン注入後の水素雰囲気中の熱処理が実施されないため、このようにイオン注入量が少ないと、ブリスタが発生しない。特に、実施例3では質量の重いヘリウムイオンを先に注入することで、相対的に軽い水素ガスイオンに比べて効果的にイオン注入領域11aが形成され、この後に注入された水素ガスイオンの注入分布幅をシャープにするため、イオンのトータル注入量が実施例1及び2よりも少ないが、ブリスタを生じる。

【0016】

【発明の効果】以上述べたように、本発明によれば、第1シリコン基板の表面に酸化膜を形成し、第1シリコン基板の表面から水素ガスイオン、水素分子イオン、ヘリ

*す。なお、上記熱処理後に酸化膜表面のブリスタの発生の有無を調べた理由を述べると、本発明の方法でSOI基板を製造するためには、第1基板11と第2基板13とを密着させて熱処理した場合、第1基板11のイオン注入領域11bで気泡が発生することが必要であり、この気泡が発生すると酸化膜12表面にブリスタが発生するためである。即ち、ブリスタの発生の有無によりイオン注入領域11bでの気泡の発生の有無を判断できるからである。

【0014】

【表1】

ウムイオン及びシリコンイオンからなる群から選ばれた1種又は2種のイオンを注入して、第1シリコン基板内部にイオン注入領域を形成し、第1シリコン基板を水素雰囲気中で 400°C 以下の温度で熱処理し、第1シリコン基板を上記酸化膜を介して第2シリコン基板に重ね合わせて密着させ、第1シリコン基板を第2シリコン基板に密着させたまま熱処理するようにしたから、少ないイオン注入量で効率的にイオン注入領域に気泡が発生する。即ち、本発明では第1シリコン基板を効率的にイオン注入領域で厚内部と薄いシリコン層とに分離できる。この結果、短時間でイオン注入を行うことができるので、SOI基板の生産性を向上できる。

【図面の簡単な説明】

【図1】本発明実施形態のSOI基板の製造方法を工程順に示す図。

【符号の説明】

40 11 第1シリコン基板
11a イオン注入領域
11b シリコン層
12 酸化膜
13 第2シリコン基板

【図1】

